CEMENT AND LIME MANUFACTURE

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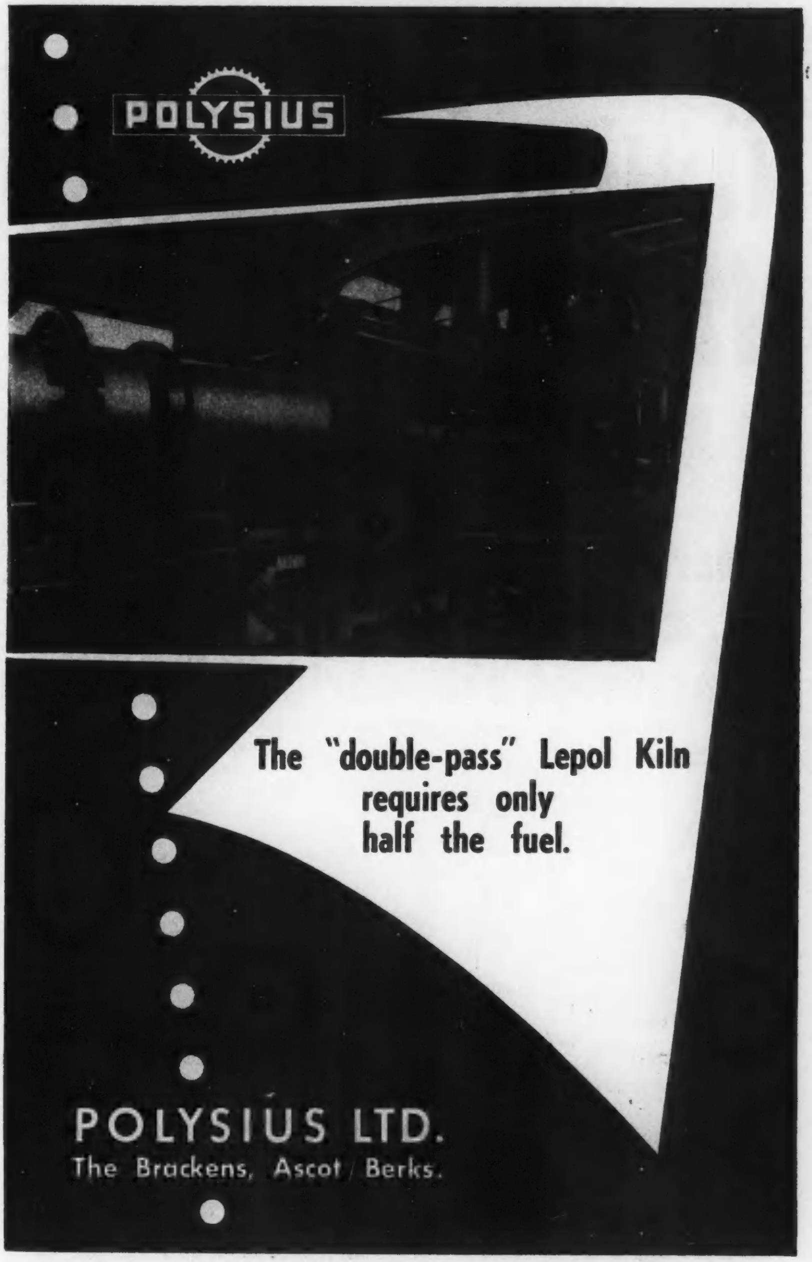
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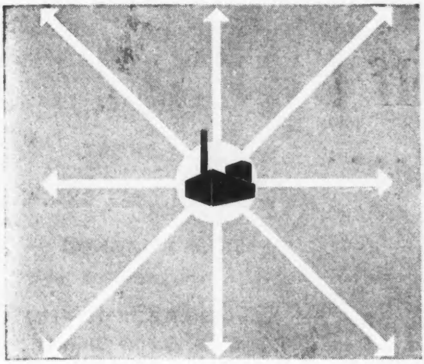

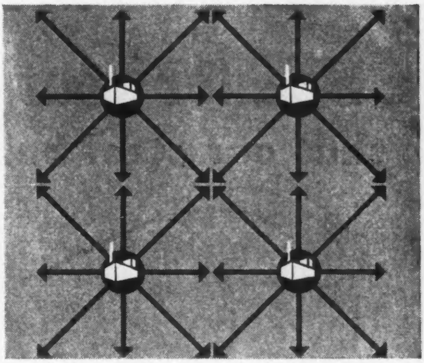

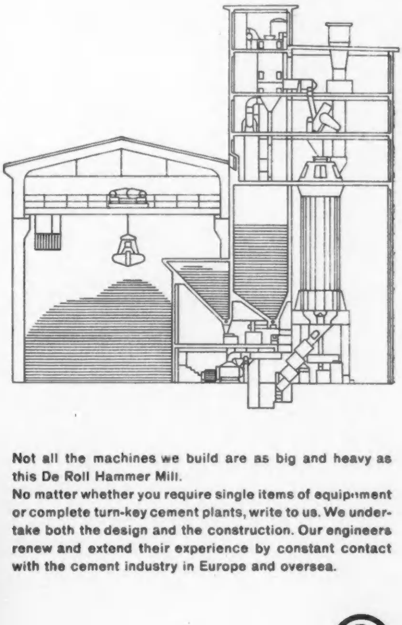

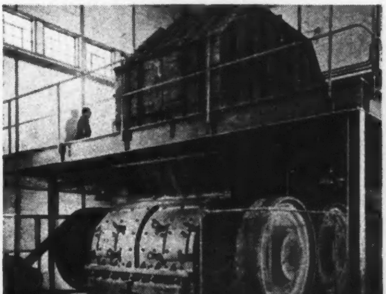


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A New Cement Works in the U.S.A.

THE NEW cement works of the Alpha Portland Cement Co., at Lime Kiln, Maryland, U.S.A., which has an annual capacity of 375,000 tons, commenced production in 1958 and is described in "Pit and Quarry" for July 1959, from which the following is abstracted. The works, which operates on the wet process, was designed to produce ordinary Portland cement (Type I) but all types of standard cements can be made. The site was purchased in February 1956, and the first of the two kilns was in operation in May 1958. Wherever possible the movement of materials is remotely controlled. There are 89 men on the day shift and twelve on each of the two night shifts, when all the plant is operated except the quarry, the crushing and screening plant, and the despatch department. The arrangement of the works is shown in *Fig.* 1.

Raw Materials.—The raw material is limestone obtained from two quarries and mixed together. Enough of the overburden of clay is allowed to remain to provide the required mixture when the stone is blown down with explosives. Four drills are used to make blasting-holes 3½ in. in diameter and 9 ft. apart vertically and horizontally. The charges in three rows of thirty-three holes each are usually fired together. Dynamite is used, and about 2½ tons of stone are obtained for each pound of explosive. A swinging ball weighing 6000 lb. and wielded by a mobile crane is used to break the debris.

The stone is loaded by 2½-cu. yd. electric shovels into trucks of 17 cu. yd. capacity which discharge it into a vibrating hopper. Material larger than 5 in. enters the primary jaw-crusher and material smaller than 4 in. joins the product from the crusher on a belt-conveyor and is carried to the secondary crusher, which has twelve 325-lb. hammers driven by a 700-h.p. motor at 890 revolutions per minute. Here 90 per cent. of the stone is reduced to ¾ in. or less and is carried by two conveyors to a pair of screens which separate material larger than ¾ in. and return it by gravity to the secondary crusher. Material less than ¾ in. in size is carried on a conveyor to a store and is sprayed with water to prevent

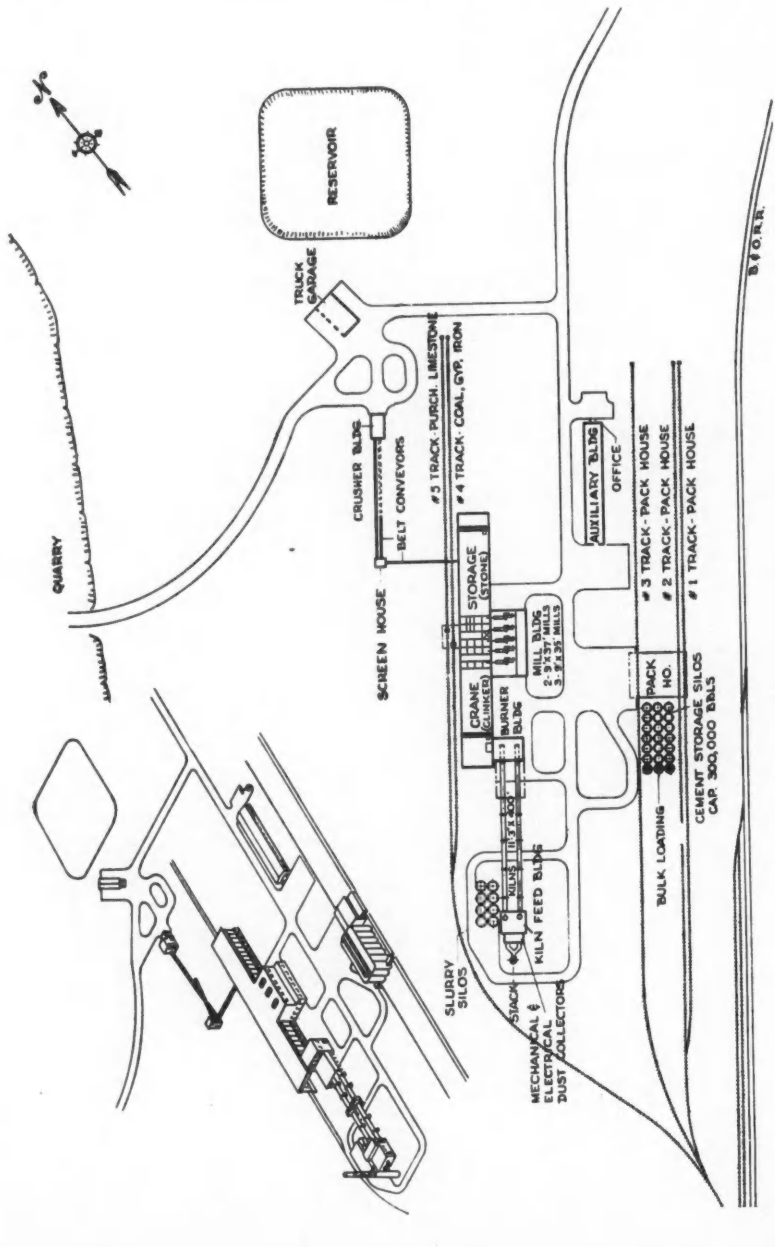

Fig. 1.—Arrangement of the Works.

dust; the spray is stopped by a solenoid when the flow of material stops. Three dust collectors are installed in the crushing buildings.

Separate stores are provided in a building 80 ft. wide and 680 ft. long for 31,000 tons of stone, 3600 tons of gypsum, 500 tons of sand, 500 tons of iron, 4500 tons of coal, and 16,500 tons of clinker. About 10 per cent. of stone with a very high content of calcium is used in the mixture and is obtained from sources distant from the works. A crane takes stone, ore, and sand to two sets of storage bins each of which has five bins of 343 tons capacity. Two other bins in each set contain shale or clay and purchased limestone.

Water is added as the raw material is discharged to the two grinding mills. These are tube mills 9 ft. in diameter by 37 ft. long, each driven at 18 revolutions per minute by a 1250-h.p. synchronous motor through a magnetic clutch. Each mill contains 114 tons of carbon-manganese forged steel grinding balls, 32 tons of 3-in. to 2½-in. diameter balls, 39 tons of 2-in. to 1½-in. diameter balls, and 43 tons of 1½-in. to 1-in. diameter balls, in the first, second, and third compartments respectively. Slurry from these mills is ground until 87 to 90 per cent. passes a 200-mesh screen; it has a water-content of 35 per cent. About 50 tons per hour are produced by each mill, and the slurry is discharged over 4-ft. by 5-ft. screens which remove all material too large to pass the 50-mesh screens. This material is returned to the mills. The slurry passing through the screens is pumped to six of eight storage tanks.

Blending the Slurry.—The eight slurry tanks are each 29 ft. in diameter by 30 ft. high, with a capacity of 19,000 cu. ft., and have mechanical and air agitators. Slurry from the six storage tanks is pumped to two blending tanks; more accurate blending can be carried out when pumping to the two final or kiln-supply tanks. If desired, the slurry can be blended directly from four of the storage tanks to the other four tanks for delivery to the kilns. In the office a control board has indicators for levels of the slurry. Two 6-in. pumps (one is in reserve) deliver the blended slurry to the two constant-level kiln-supply tanks whose supply is connected with the motors driving the kiln to maintain a constant rate of delivery. Any overflow from these tanks is returned by gravity to the storage tanks. At the delivery to each kiln there is a vortex mixer for blending dust from either the mechanical or electrical dust collectors, or both.

The Kilns.—The two kilns are 11 ft. 3 in. in diameter and 400 ft. long. They are mounted on six sets of rollers and are inclined ⅜ inch in 1 foot. They are driven at the rate of sixty revolutions per hour by two variable-speed motors of 60 to 75 h.p. operating at 300 to 1200 revolutions per minute. Both kilns are equipped with a 60-ft. chain system of the helical-suspension type, containing 7425 ft. of chain with links of 1-in. diameter steel and weighing about 45 tons. These chains are fixed to the shell of the kiln. At the discharge end the kilns are lined for a distance of 10 ft. with 40-per cent. alumina bricks and for 5 ft. with 70-per cent. alumina bricks. In the burning zone the lining is successively 50 ft. of Magnecon bricks, 25 ft. of 70-per cent. alumina bricks, 25 ft. of Spallac

bricks, 134 ft. of 4½-in. Armstrong A-23 bricks, and 50 ft. of 40-per cent. alumina bricks. There is no lining for a distance of 84 ft. at the chain section and 16 ft. at the entrance.

The clinker is discharged into coolers with three compartments and a horizontal grate. The fan has a capacity of 47,000 cubic feet per minute and a multiple-cyclone collector returns the dust to the last section of the cooler. Clinker is discharged to a hammer-mill from which it is taken by a conveyor to a pit from which a crane takes it to the store. This crane also transfers material from storage to the finishing mill.

The fuel is coal with a heat value of 14,000 B.t.u. and low sulphur content and is ground to a fineness such that 97 per cent. passes through a 100-mesh screen and 98 per cent. through a 60-mesh screen. Fuel, with air at a temperature of 150 deg. F., is injected into the kilns through a burner of 12-in. diameter. Drying-air from the cooler, which passes through a cyclone collector to remove the dust, is heated to about 600 deg. F. Coal is delivered to the screens by conveyors and is discharged into two 50-ton hoppers over the coal mills. This operation is automatically controlled. When the supply of coal is stopped the feeder under the main coal bin stops five minutes before the conveying equipment in order to allow time for unloading.

Gases at a temperature of 600 deg. F. are drawn from the kilns through a dust chamber and flue to a mechanical dust collector, with two sets of 12-in. to 24-in. tubes, which removes 60 to 70 per cent. of the dust, and then pass to an electrostatic precipitator having two parallel systems of four compartments each; this precipitator removes 95 per cent. by weight of the dust entering it. The draught fans have a capacity of 140,000 cubic feet per minute at a pressure equal to 7 in. of water. Both fans vent into a reinforced concrete stack which is 300 ft. high and has an external diameter at the base of 33 ft. and an internal diameter of 19 ft. Dust is reclaimed from the collectors by 10-in. screw-conveyors and bucket-elevators so arranged that any desired part of the dust can pass to the kiln if required.

The temperature at the back end of the kiln is kept as nearly as possible at 600 deg. F. Draughts are kept as closely as possible to 1 in. at the inlet to the coal mill, 0·1 in. in the kiln hood, and 1½ in. to 2 in. at the back end. The primary air pressure is maintained between 10 in. and 15 in. Other temperatures average about 900 deg. at the grate in the coolers, 175 deg. in the coal mills, 2800 deg. in the burning zone, and 500 deg. or less at the stack. The average production of the two kilns is close to their designed combined capacity of 1080 tons daily of ordinary Portland cement. The fuel consumption is 90 lb. of coal, or 210,000 B.t.u., per ton. Each kiln is controlled from a cubicle where the instruments include an oxygen analyser; temperature indicators and recorders for twelve points in the kiln, the cooler, the coal mill, etc.; draught indicators; ammeters; and speed indicators.

There are three mills for fine grinding; one is for gypsum, another for clinker and the third for limestone for masonry cement. Each of the mills is 9 ft. in diameter and 35 ft. long with three compartments and is driven at a speed of 18

revolutions per minute by a synchronous motor. The weight of balls is the same as in the mills for raw material. Grinding is such that 95 to 96 per cent. of the material passes a 200-mesh screen, that is, a specific surface of 1850 sq. cm. per gramme for ordinary (Type 1) Portland cement.

Storing and Packing Cement.—The eighteen silos for storing cement are each 28 ft. in diameter by 110 ft. high, and are arranged in three rows; the total capacity is 50,000 tons. At one end, and separate from the others, are three silos for loading loose cement, each 28 ft. in diameter by 55 ft. high having four compartments and each having a capacity of 1333 tons. Under each row of silos is a self-propelled 8-in. pump which can deliver either to the three silos used for despatching loose cement or to the packing station. There are three packing machines. each of which has its own system for loading lorries or railway trucks.

Revised Foreign Standards for Portland Cement.

During 1959, the standards for Portland cement in France and South Africa were revised in some minor particulars which are given in the following.

French Standards.

The French standards (P15-302) published in 1959 relate to four types of Portland cement, namely,

CPA (160–250) and CPA (250–315).—Ciment Portland ordinaire.
HRI (315–400).—Ciment Portland à haute résistance initiale.
SUPER (355–500).—Superciment.

The requirements are the same as in the previous edition except that no test for fineness is now required for cement type CPA (250–315), which was the only cement in the previous edition to which such a test was applicable. The maximum SO_3-content allowed has been increased from 3 to 3½ per cent. The compressive strength of super-cement at two days is now specified, the minimum strength required at this age being 200 kg. per square centimetre (2845 lb. per square inch). The cold water storage test is not now required.

South African Standards.

The requirements of the revised 1959 standards for South Africa are similar to British Standard No. 12, as hitherto, except that one of the tests for fineness is that the residue on a No. 72-sieve shall be not more than 1·2 per cent. by weight for ordinary Portland cement and 0·5 per cent. for rapid-hardening Portland cement. An optional test of the transverse strength of concrete cubes is included; ordinary Portland cement shall have a transverse strength at three days of 250 lb. per square inch and at seven days of 400 lb. per square inch. Rapid-hardening Portland cement shall have a transverse strength at three days of 400 lb. per square inch and at seven days of 550 lb. per square inch. The loss on ignition shall not exceed 4 per cent. for all cements.

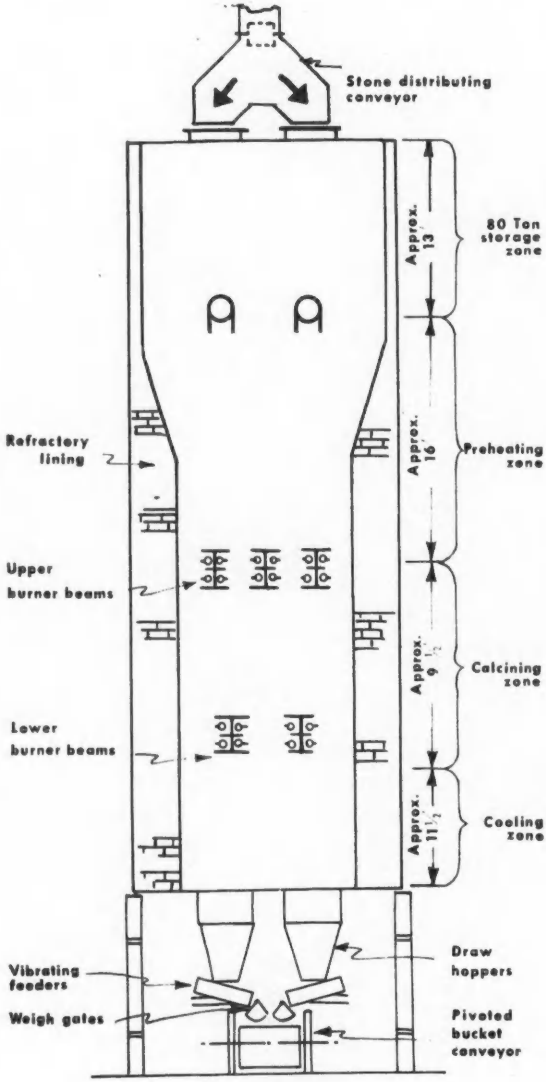

Fig. 1.—Lime Kilns.
(See facing page.)

Increasing the Efficiency of Lime Kilns.

IMPROVEMENTS made to the burning system and to auxiliary mechanical equipment have increased the output of three vertical lime kilns at the works of the Union Carbide Co., at Ashtabula, Ohio, U.S.A., from 100 tons to more than 450 tons daily. The amount of unburned material has been reduced from 10 to 12 per cent. to 3 to 3½ per cent., the consumption of power by the electric furnaces

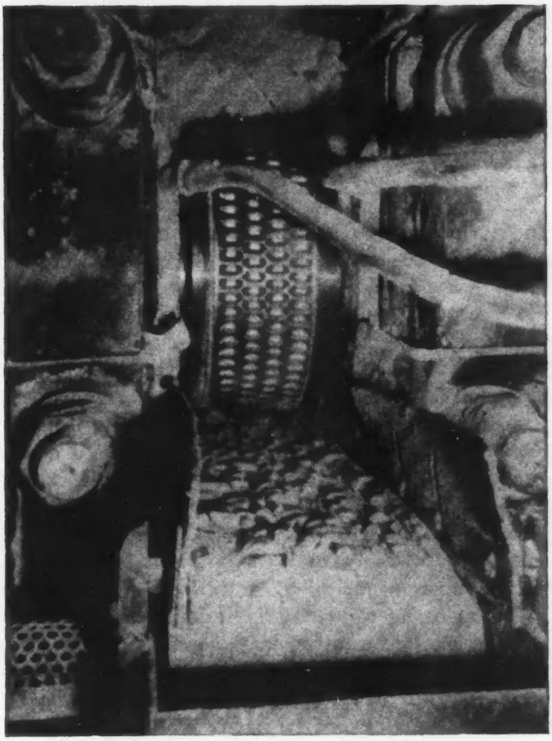

Fig. 2.—Press for Making Pellets.

is reduced, and the size of the raw material has been increased from 3½ in. by 2 in. to 5½ in. by 3½ in.

The kilns are 50 ft. high and 11 ft. square in cross-section. A large induced-draught fan has been added to each kiln to remove the exhaust gases and reduce the internal pressure. About 60,000 cu. ft. per minute of gas at 600 deg. F. is

extracted from each kiln and passed through a pair of wet-scrubbers from which it is discharged to the atmosphere by a smaller fan. Most of the dust removed by the scrubbers is limestone since the powdered quicklime is caught near the top of the kiln by the charge of cold limestone, and returned. About 80 tons of limestone are contained above the exhaust ducts, which are provided with hoods to prevent the limestone from being drawn into the exhaust system. The gases, as they pass through the ducts, are analysed continuously to determine the amounts of carbon monoxide, carbon dioxide and oxygen present. This information is used to regulate automatically the amount of fuel and its composition, the speed of the exhaust fan and the flow of the material through the kiln.

Five sets of burners are contained in water-cooled box girders which are placed across each kiln (*Fig.* 1). The pipes supplying fuel and water pass along the inside of the beams and gas is burnt at jets at intervals along the sides. The beams are capable of supporting the stone above them if it should collect on them and will not deform at the operating temperature of 1500 deg. F. if the supply of cooling water is interrupted for a short period. The lower beams are particularly susceptible to the accumulation of lime, which is almost at its greatest temperature in that area and pneumatically-operated bars are provided which can be passed through the wall of the kiln to remove any lime which has fused to the beams.

It is important that the finished product is drawn from the entire cross section of the kiln and a system has been installed which operates on a timed cycle determined by the rate at which the fuel is used, since this rate controls the rate at which the kiln works. Six vibrating feeders are provided under each kiln and supply hot lime from the kiln to containers. When the required weight has been supplied to a container, the feeder stops automatically and the container discharges to a bucket-conveyor below. This discharge is synchronised with the conveyor so that it can only occur when there is an empty bucket beneath the container.

The fuel for the kilns is mainly waste carbon monoxide produced in electric-arc carbide furnaces for which the lime is required. The gas is about 80 per cent. pure and is mixed with enough natural gas (of about 1000 B.t.u. per cu. ft.) to produce a constant supply of fuel of 250 B.t.u. per cu. ft. The mixture of the gases is controlled by means of a recording calorimeter in each stream of gas. Strict safety precautions are enforced in the vicinity of the carbon-monoxide system and the mixing area is in a vapour-tight enclosure. A small amount of ethyl mercaptan is added to the carbon monoxide so that any leaks can be noticed immediately; gas masks and oxygen masks are available. Pressure relief valves are included in the fuel pipes.

Any lime of a size less than ¼ in., which cannot ordinarily be used in an electric furnace, is sent to a press (*Fig.* 2) and passes between two rollers which compress it into pellets about 1½ in. by ½ in., in which form it is suitable for electric furnaces.

A closed television circuit is used to observe the hot lime on a conveyor so that the condition of the lime is under constant surveillance.

These notes are abstracted from " Rock Products," October, 1959

Variation of the Strength of Portland Cement.

EXPERIMENTS have been carried out recently in Britain and the U.S.A. on the variation of the strength of Portland cement produced at the same works and at different works.

Tests of British Cements.

In the " Magazine of Concrete Research," November 1958, Mr. P. J. F. Wright describes a statistical examination of records, accumulated by the Road Research Laboratory, to determine the relative importance of the causes of variation of the strength of Portland cement as represented by the crushing strengths of cubes of mortar and concrete made and tested in accordance with British Standards Nos. 12 and 1881. It was found that when cubes of mortar were made from the same batch of cement the variation of their crushing strengths was due mainly to differences in the preparation and testing of the cubes and usually increased with the age of the samples. The standard deviation of the crushing strengths in one case increased from about 150 lb. per square inch at three days to about 280 lb. per square inch at twenty-eight days. The coefficient of variation was about 4 per cent.

The variation between batches of cement from a particular works, may have a standard deviation greater than 400 lb. per sq. in., but which may decrease with the age of the specimens. In one case the coefficient of variation decreased from 25 per cent. at three days to 8 per cent. at twenty-eight days. Tests of cement delivered during a period of more than four months showed an increase of variation probably due to random and long-term differences in the cements. The variation between the crushing strengths of cements from different works was about 620 lb. per sq. in., that is about 13 per cent. of the average strength.

In a discussion on Mr. Wright's article, Mr. E. Burke refers to the great variation of the quality of the raw materials from which cement is made, and in the quality of coal, and points out that without expensive blending and other measures which might be difficult to put into practice, it is impracticable to produce a cement strictly uniform in quality, and that were such a cement produced the saving in quantity of cement used would be outweighed by the increased cost of production.

American Tests.

In the Proceedings of the American Society for Testing Materials, Vol. 58, 1958, Mr. S. Walker and Mr. D. L. Bloem describe the results of tests on samples of cement obtained every two weeks during a year from each of five sources. The results were compared with those for a mixture of five brands of cements which was stored in sealed containers and used as a standard of comparison. The tests comprised crushing of specimens of mortar of all the cements and of concrete made with some of the cements. The variation of the results from the average are given in *Fig.* 1. Generally the strengths of mortars made with the mixed cements did not vary by as much as 5 per cent. above and below the average. The strengths of mortars made with five different cements varied respectively from 2 per cent. above to 20 per cent. below; from 18 per cent. above to 18 per cent. below; from

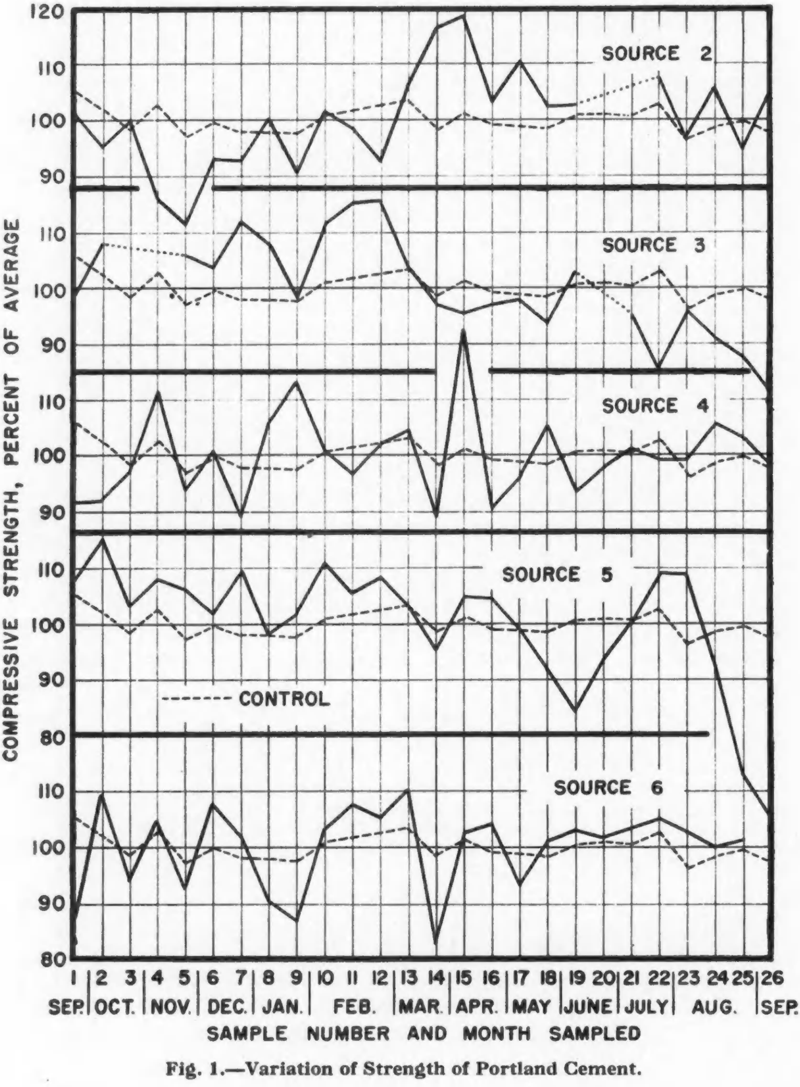

Fig. 1.—Variation of Strength of Portland Cement.

22 per cent. above to 10 per cent. below; from 15 per cent. above to 33 per cent. below; and from 10 per cent. above to 16 per cent. below. The strengths of cubes of concrete made with the same cements varied almost exactly as the variations of the strengths of the mortars made with the same cements.

Terminology and Testing of Cement.

AT the third meeting of the committee of the International Standards Organisation dealing with hydraulic binders, which was held recently in Warsaw, the terminology and classification of cement and plaster, and methods of chemical analysis and testing of the strength of cement were discussed. Delegations from seventeen countries were present, including representatives of the International Union of Testing and Research Laboratories for Materials and Structures (RILEM) and the International Association of Cement Manufacturers (CEMBUREAU). The extracts of the proceedings of the meeting given in the following are taken from "B.S.I. News" for January 1960.

Cement is defined as "finely-ground material forming, by the addition of an appropriate quantity of water, a binder capable of hardening both under water and in the air and agglomerating suitable substances. The addition of other substances (air entrainers, plasticisers, accelerators, hydrophobic additives, etc.) in small quantities not exceeding 3 per cent. shall be covered by a statement of their general nature." Ordinary and hydraulic limes, plasters and masonry binders are excluded.

"Pozzolanic Portland cements" may contain up to 20 per cent. pozzolana but need not pass the test for pozzolanicity. "Pozzolanic cements" may contain up to 40 per cent. pozzolana and must pass the test for pozzolanicity.

Blastfurnace cements are classified by their slag content.

Comments on chemical analysis of cement were put forward by delegates from the United Kingdom and were accepted. The mortar prism test for the strength of cement recommended by the Rilem-Cembureau was adopted by a majority but was opposed by the United Kingdom delegation, which tabled a note introducing the concrete test given in B.S. No. 12; a sub-committee, on which the United Kingdom is represented, was set up to consider this matter.

A Large Cement Works in Russia.

THE two 575-ft. kilns which have been installed at the cement works at Acympt, Siberia, and which are described in this journal for January 1960, are claimed to make this works one of the largest in the world. The capacity of the works will be about 5500 tons of cement a day; this tonnage is not the capacity of each kiln as stated in the previous article.

The analysis of the nepheline residue, which is mixed with the limestone, is approximately as follows: Al_2O_3, 2·5 to 3 per cent.; Fe_2O_3, 2·5 to 3 per cent.; SiO_2, 30 to 31 per cent.; CaO, 56 to 57 per cent.; R_2O_3, 2 to 2·3 per cent.; P_2O_5, 0·2 per cent.; SO_3, 0·3 per cent.; and miscellaneous constituents, 3 to 4 per cent.

The analysis of the slurry as fed to the kilns is as follows: SiO_2, 15·69 per cent.; Al_2O_3, 3·86 per cent.; Fe_2O_3, 3·22 per cent.; CaO, 51·01 per cent.; MgO, 1·21 per cent.; SO_3, 0·42 per cent.; K_2O, 0·32 per cent.; and Na_2O, 0·62 per cent. The loss on ignition is 23·55 per cent. The residue on a 4,900-mesh sieve is 6·00 per cent.

The coolers are of the Fuller type and are 75ft. long and 14ft. wide, and were supplied by the Société Constantin of Paris. The clinker is conveyed on two drag chains each having a capacity of 104 tons per hour.

The Cement Industry Abroad.

IN the following are given reports on the production of cement and extensions of cement works in various countries.

Formosa.

THE cement works at Taiwan (Formosa) are to be extended so as to increase the production by 60 per cent. within a period of three years. Extensions are proceeding to five works and are expected to be completed by 1962. The Taiwan Cement Corporation is to increase production at its Kaohsiung works (*Fig.* 1) in southern Taiwan and intends to build another works at Hualien on the eastern coast of Taiwan. Two other private cement companies are also increasing production as is also the Asia Cement Corporation.

Cement production in Taiwan has doubled in a period of only five years to the present output of 1,000,000 tons annually, about one-third of which is exported,

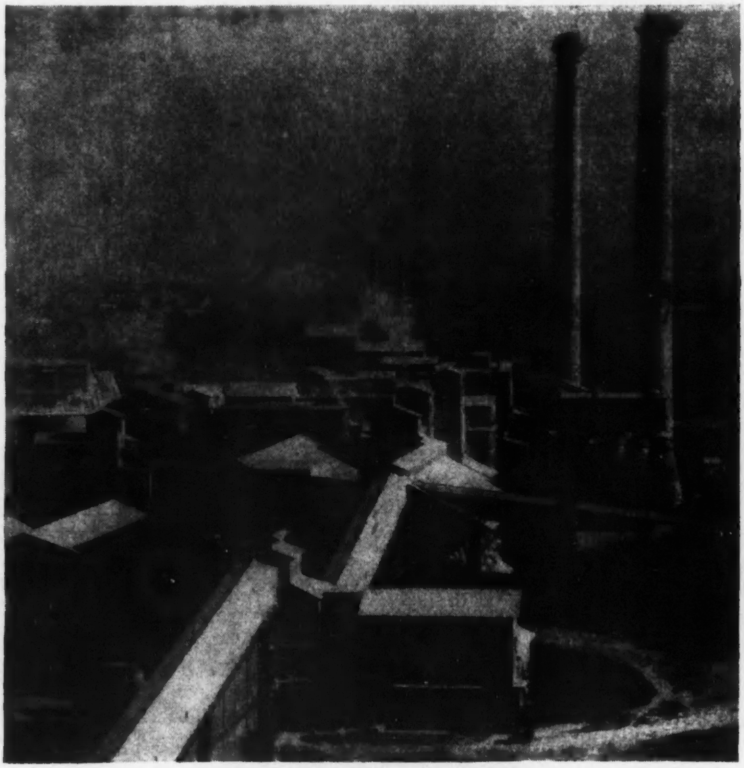

Fig. 1.—Taiwan Cement Works, Formosa.

mostly to south-east Asia. When the extensions are completed the production is expected to increase to 1,600,000 tons annually.

Hungary.

It is proposed to increase the capacity of the cement industry in Hungary from the present rate of 1,300,000 tons to 2,200,000 tons a year by 1965. This country is also to spend about £24,000,000 this year on investments in the building-materials industry. The largest single investment will go to the Danube Cement & Lime Works which is in course of construction at Vác, about twenty-one miles north of Budapest. By 1965, it is expected that this works will be producing 1,000,000 tons of cement annually.

Thailand.

The new cement works of the Irrigation Cement Plant Co. at Phone Thong started production in August last. The capacity is 100,000 tons a year, and it is intended that this shall be trebled.

Switzerland.

In the year 1958 the production of cement in Switzerland was 2,170,000 tons, compared with 2,500,000 tons in 1957. During the year 1958 the capacity of the industry was increased by 400,000 tons.

Shanghai.

A new kiln with a yearly capacity of 100,000 tons of Portland cement has started production at the Shanghai cement works, and a factory has been built at Kuching with a yearly capacity of 7000 tons of white cement.

Patent Application for Slag Cement.

In the production of an hydraulic binding material from blastfurnace slag, glassy granulated slag is drained, preferably to a moisture content of less than 15 per cent., crushed, for example to a fineness of about 50 microns, and the slag particles are further reduced by subjecting them in an endless conduit to high-velocity gas jets. Steam at a gauge pressure of 150 lb. to 175 lb. per square inch or compressed air may be employed. Slag is fed through inlets to an annular conduit into which gas jets are directed through nozzles; the pulverised particles are drawn by the gas upwardly through the exit. The fineness of the product may be controlled by varying the fineness of the crushed slag or the rate of supply.—British Patent Application No. 791,622. Resource Use, Ltd., December 5, 1955.

Reports on Chemical Congresses.

Two books* containing some of the lectures presented at the European Convention of Chemical Engineering and the ACHEMA Congress, held in Frankfurt (Main) in 1958, have been published recently.

The subjects of the twenty-eight papers in the first volume include automation (such as the work of Edy Velander of Stockholm), practical problems of regulation and control, and instrumentation. Among the matters dealt with are the important progress and developments which have been made in potentiometry, chromatography (particularly in gas chromatography), the determination of oxygen, spectroscopy, the measurement of turbidity, temperature, humidity and the rate of combustion, flame photometry, dosing equipment and flow meters, dielectric and other methods of measurement, and the calculation of Bourdon springs.

The second volume completes the reports of the lectures, the subjects dealt with concerning mainly the testing of materials and the properties and application of structural materials.

The papers are in German but summaries are given in English and French.

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* "Mess-und Regeltechnik". Dechema Monographs, Vol. 35 (327 pages. Price DM.39.40). "Werkstaff-Technik." Dechema Monographs, Vol. 36 (280 pages. Price DM.32.50). Verlag Chemie GmbH: Weinheim/Bergstrasse.

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